Computer Controlled Systems II – Diagnosis

Problem statement for individual projects

DISCRETE METHODS

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Jan 2020

Overview

1. Dynamic system model specification

2. Tasks to be carried out

Simple dynamic systems

System dimensions:

- maximum 2 state variables (state equations)
- maximum 2 input variables (held constant for the task!, i.e. no variation in time)
- maximum 1 output variable (sensor)
- maximum 2 faults

Simple possibilities are on the next slides!
Each student should have a different system

Simple examples – 1

A *Room temperature with controller*
Consider a room with fixed heat capacity that has an electrical heating device in it equipped with a binary switch. A conventional on/off controller keeps the room temperature near a prescribed level such that it switches on the heater if the temperature falls below a certain level, and switches it off when the temperature reaches a higher prescribed level. The system fault is when someone leaves the window open. An additive sensor fault for the measured temperature is considered.

B *Bathroom boiler* István Balázs
Consider a container (tank) of water in a bathroom with fixed heat capacity that has an electrical heating device in it equipped with a binary switch. A conventional on/off controller keeps the water temperature near a prescribed level such that it switches on the heater if the temperature falls below a certain level, and switches it off when the temperature reaches a higher prescribed level. The system fault is when someone takes a bath, i.e. replaces part of the water in the tank with a much cooler charge. An additive sensor fault for the measured temperature is considered.

Simple examples – 2

C *Toilet water tank*
Consider a toilet that has an a water tank equipped with a level sensor, a knob for emptying it, an outlet valve, and an inlet binary valve that is controlled by the level sensor. Consider the usual operation sequence: with the tank full and both valves closed one pushes the knob, that empties the tank and then the water is re-filled through the opened inlet valve till it is closed by the level controller. The system fault is when the outlet valve can not close completely. An additive sensor fault for the level is considered.

D *Pressure tank of a pneumatic system* Márton Gréber
Consider a central container (tank) of air in a pneumatic system that operates under constant temperature, and ha a compressor for increasing the pressure in it. The pressure will slowly decrease as a result of consumptions and very small leaks. A conventional on/off controller keeps the pressure near a prescribed level such that it switches on the compressor if the pressure falls below a certain level, and switches it off when the pressure reaches a higher prescribed level. The system fault is when a big leak or consumption appears that makes the pressure quickly decreasing. An additive sensor fault for the measured pressure is considered.

Simple examples – 3

E *Dose forming automaton*
Consider an equipment for forming doses (portions) of powder with a prescribed weight. It has a continuous inlet of powder falling into a plate, the weight of the plate is measured by a digital continuously operating scale. A controller instantaneously empties the plate when a prescribed weight is reached forming a dose. The system fault is when the powder does not leave the plate completely, but a portion of it remains there. An additive sensor fault for measuring the weight is considered.

Problem statement – modelling

Model construction

- Construct the *state equation(s)* of your system model in the form of qualitative difference equation(s)
- Construct a *logical equation* for describing the operation of the *controller* (if present)
- Construct the *output equation* (as a qualitative algebraic equation) for the *measured variable*
- Extend it with *fault description*s assuming
  - a system and a sensor fault
  - assuming permanent faults of constant magnitude
- Consider the usual qualitative range spaces $\mathcal{Q}$ and $\mathcal{Q}_e$ for the real valued signals, and the extended Boolean range space $\mathcal{B} = \{-1, 0, +1\}$ for the binary variables and for the fault indicators.

Problem statement – Diagnosis

Trace generation and diagnosis

Use the ***qualitative operation tables presented on the Tutorials***.

- Construct *traces of at least length 3* (depending on the operation of your system) from given initial state (or at least two initial states when a unique initial state is not specified by the system description) for
  - NF the fault-free system
  - F1 the case when only one fault is present (separately for each, cases F1-1, F1-2)
  - F2 the case when both faults are present
- Find *characteristic traces for each of the above four cases*, i.e. for NF, F1-1, F1-2 and F2
- Construct *diagnosers* for detecting and isolating the above NF and F2 cases.

Please, submit your solution in electronic format to the e-mail address

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